Revegetation and Soil Function Evaluation at Leviathan Mine
Summary and Recommendations
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Substrate treatment and regeneration of soil function
Presentation outline:

1. Components of overland flow and potential for surface erosion
2. Examples from field observations
3. Recommended treatments
4. Potential construction methods
5. Native plant recommendations

1. Components of overland flow and potential for surface erosion

Surface flows and potential erosion can occur under several conditions:

a) surface infiltration **rate** is less than rainfall delivery rate
(caused by compaction or a thin surface crust);

b) limited infiltration **capacity** is less than volume of rain or snowmelt
(shallow soil over a compacted layer);

c) lateral seepage at toe slopes or shallow soils
(forces subsurface flows to surface; avoid saturation);

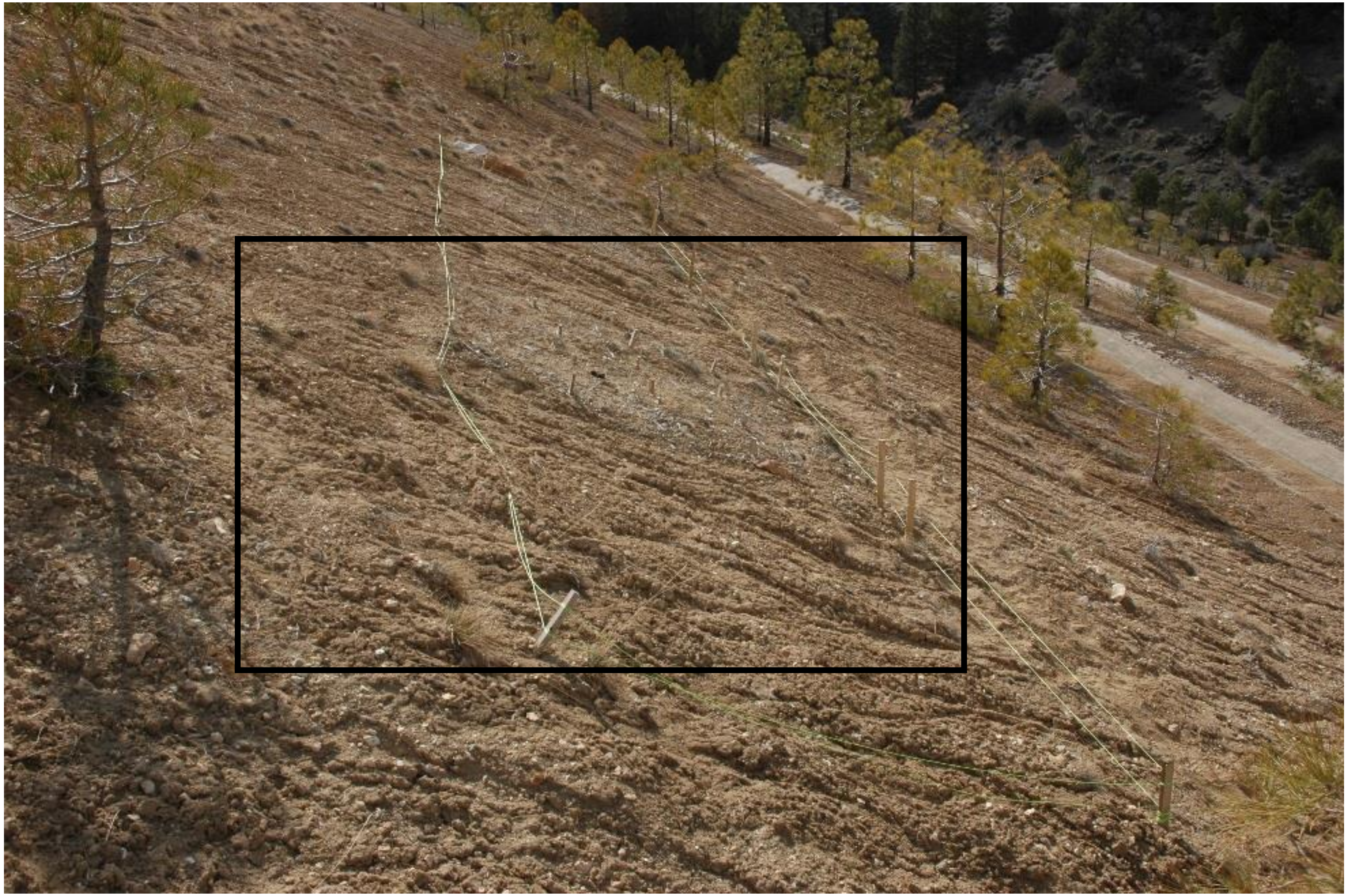
2. Examples from field observations

Insufficient infiltration rate

Figure 5. Example of crusting and rilling in the Pit Area (up slope and downslope views) from a less than 2 year return interval storm. September, 2013.

Insufficient infiltration <u>capacity</u>

Figure 9. Rills observed after winter season 2015 showing erosion at mid-slope and lower but not on the two mulched and planted demonstration plots on the Pond 2 North slope in the upper center of the photo



Insufficient infiltration <u>capacity</u>

Black rectangle is the area to be enlarged in the following image

Figure 9. Rills observed after winter season 2015 showing erosion at mid-slope and lower but not on the two mulched and planted demonstration plots on the Pond 2 North slope in the upper center of the photo

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Potential loading of drifted snow on north-facing slopes of Pond 2.

Lateral seepage
saturated subsurface pore water forced to surface by compaction or shallow soils. (December, 2015)

3. Recommended treatments

1. Slope angles shallow enough to prevent sloughing, burial of plants, sediment creep and liquefaction when saturated.

   Slopes less than 2:1 (H:V) revegetate most consistently with variable conditions.

2. Infiltration rate and capacity high enough to prevent overland flow and surface erosion.

   Minimal compaction to 3 or 4 feet, mulch the surface, maintain plant growth.

3. Moisture retention sufficient to prevent percolation below the rooting zone in a design rainfall year and to support plant growth through the dry summer season.

   The 3 or 4 ft rooting depth will maintain a dense plant canopy. The full depth must be neutralized to above pH 6.

4. Use plant species that grow sufficiently in local conditions.

   Native species are adapted to site climatic and biological conditions.

   Grasses and forbs grow rapidly. Shrubs add root strength and trap snow. Trees are larger and taller and transpire more due to their size.

The three points in red involve large-scale earthwork. The actual methods used will depend on equipment and site conditions but some practical examples are presented next.

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Potential construction methods:

BACK-FILLED BENCH

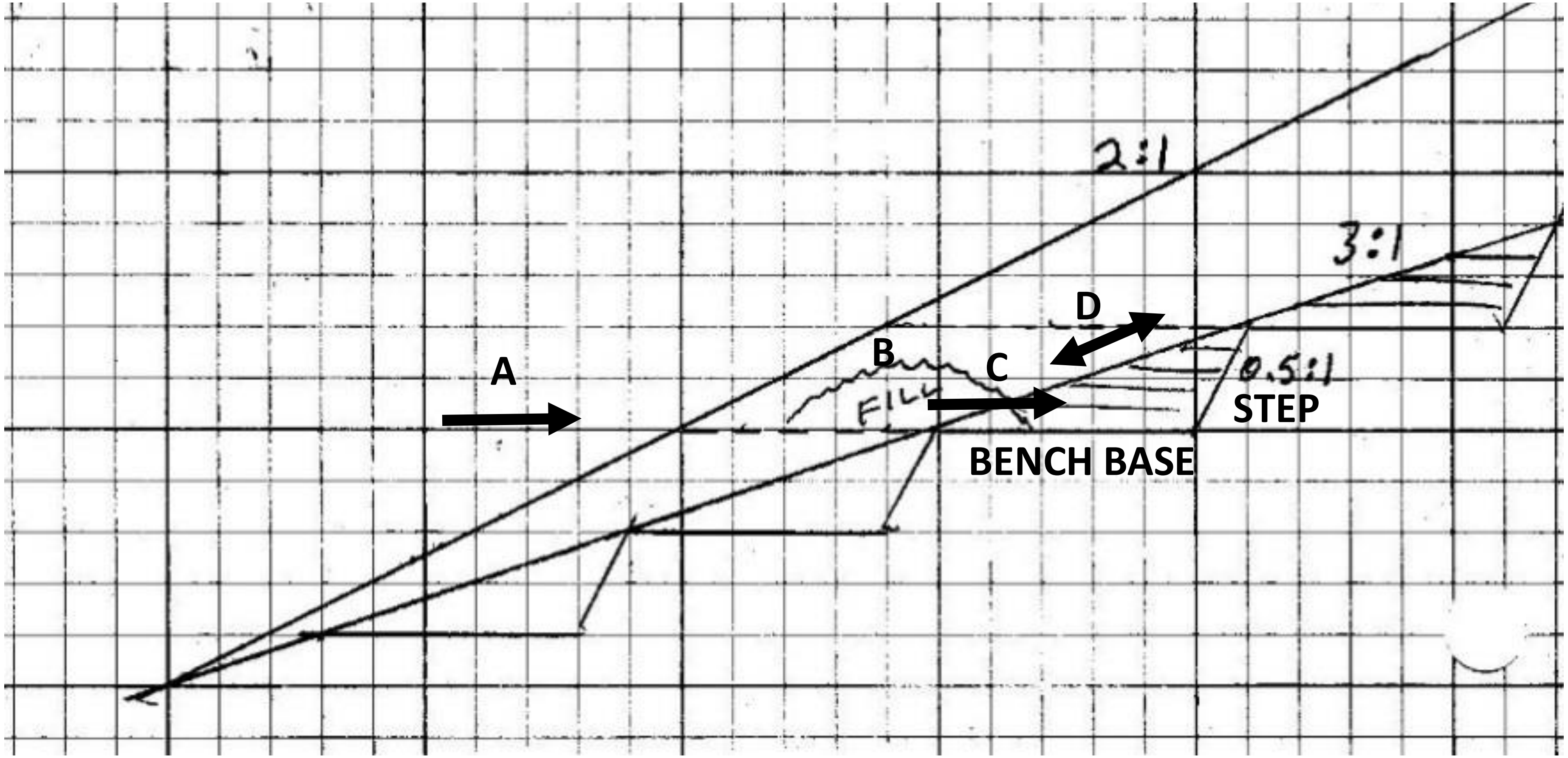
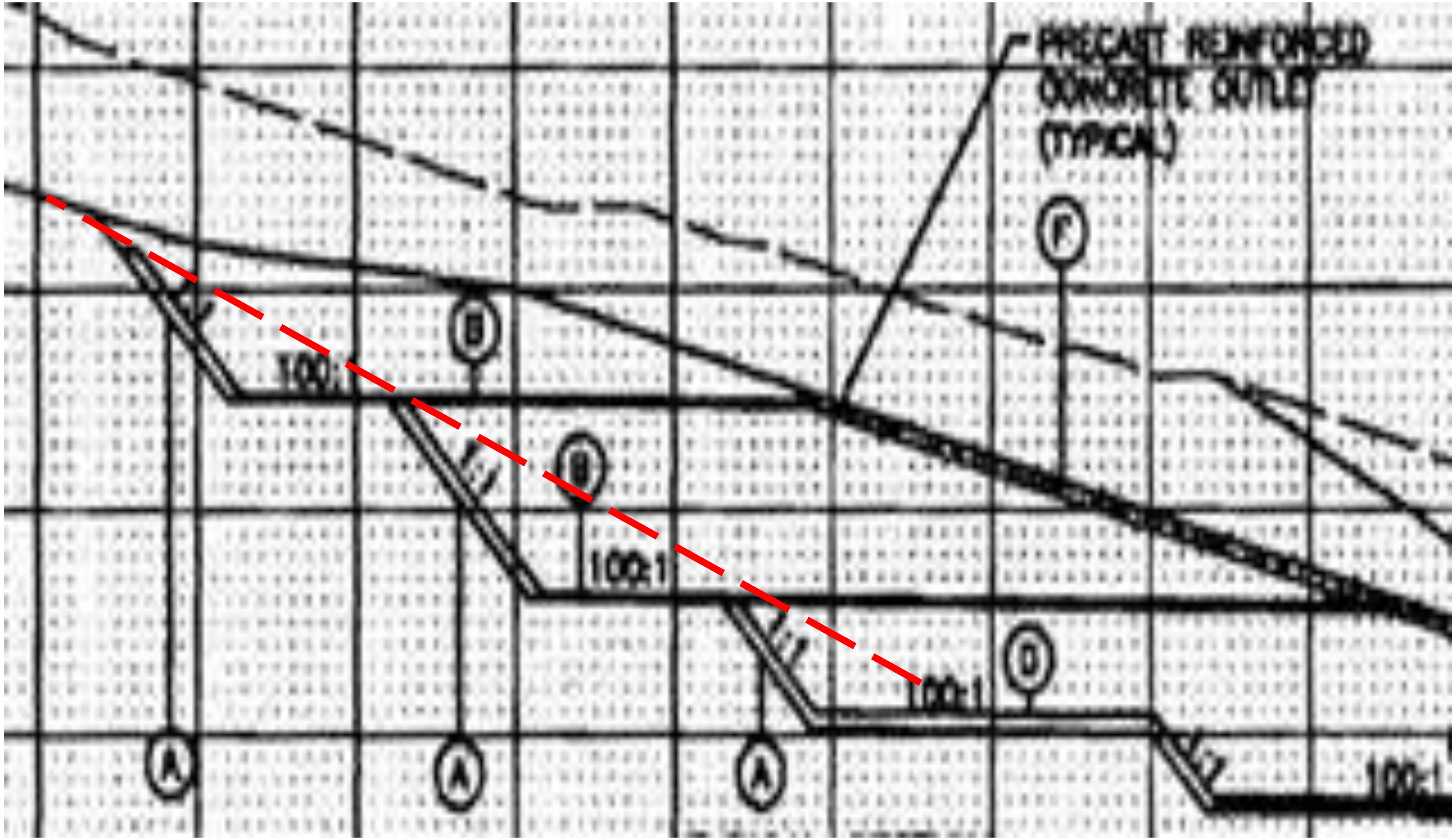


Figure 4.1. Schematic of grading sequence to reduce an existing 2:1 slope down to a 3:1 slope: 1) cut a wide horizontal bench in 2:1 slope (arrow A) with steep back wall (step) as the slope is being brought down; 2) reserve loose fill material and treat with lime and amendments (FILL pile B); 3) push amended fill into the notch of the bench in uncompacted lifts (arrow C); 4) grade 3:1 slope to uniform angle and trackwalk the uncompacted, treated fill (arrow D) to firm the amended rooting volume without additional compaction.

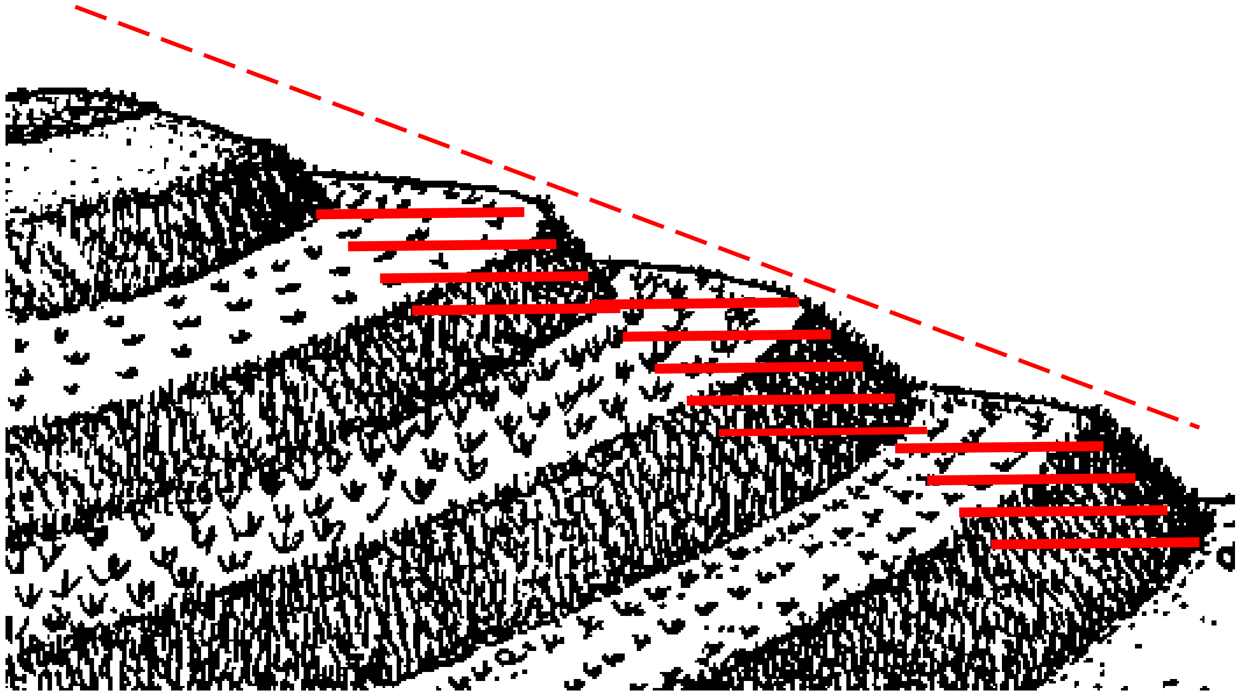


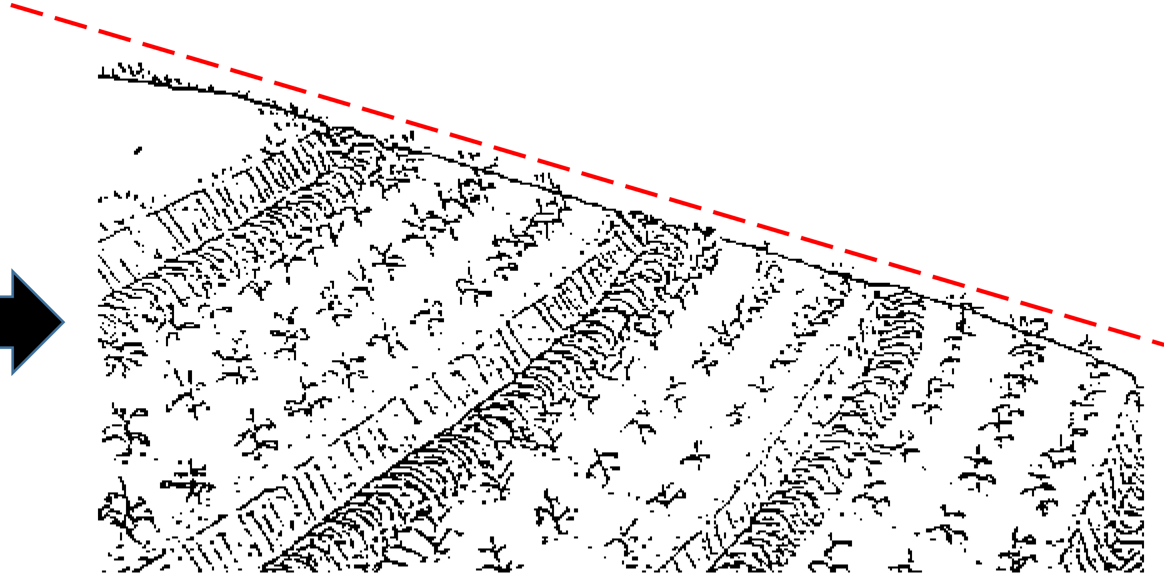
Potential construction methods:
BACK-FILLED BENCH

graphic adapted from Ohio highway design manual

http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/2009MOP/200%20Earthwork/203/203%20Roadway%20Excavation%20and%20Embankment.htm

Potential construction methods:
Offset stepped-lift construction
with uncompacted fill in the bench notches





Compacted lifts constructed at a steeper overall angle than final slope angle

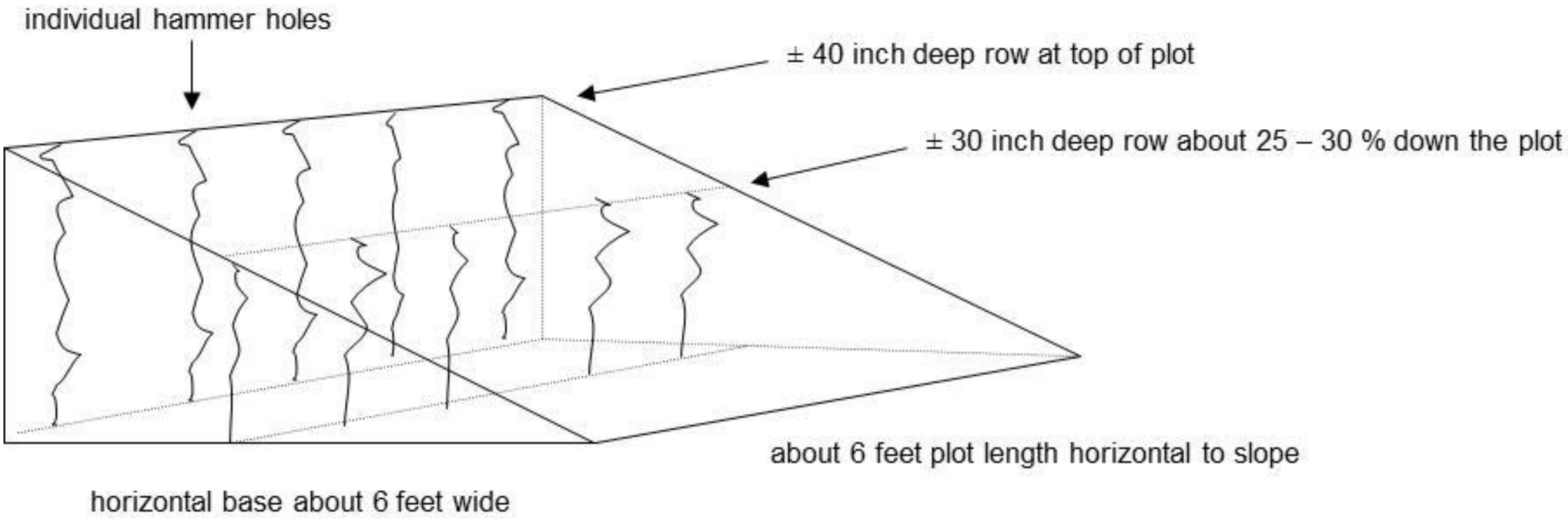
Uncompacted fill / slough pushed into notches of compacted benches

Potential construction methods:

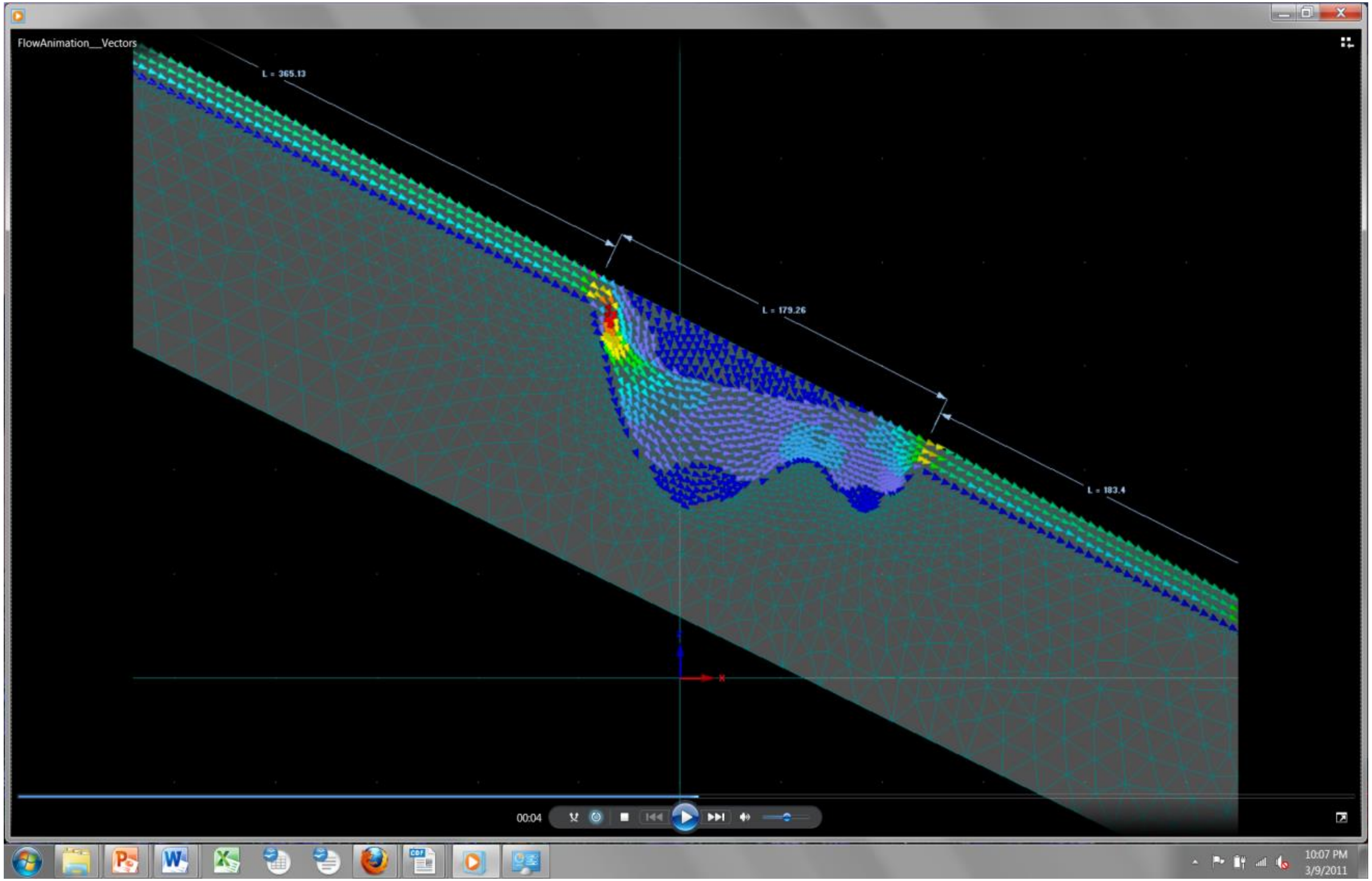
Amend each lift during construction

(Caltrans site)

http://www.dot.ca.gov/hq/LandArch/16_la_design/guidance/ec_toolbox/steep_slopes/recp_flap.htm



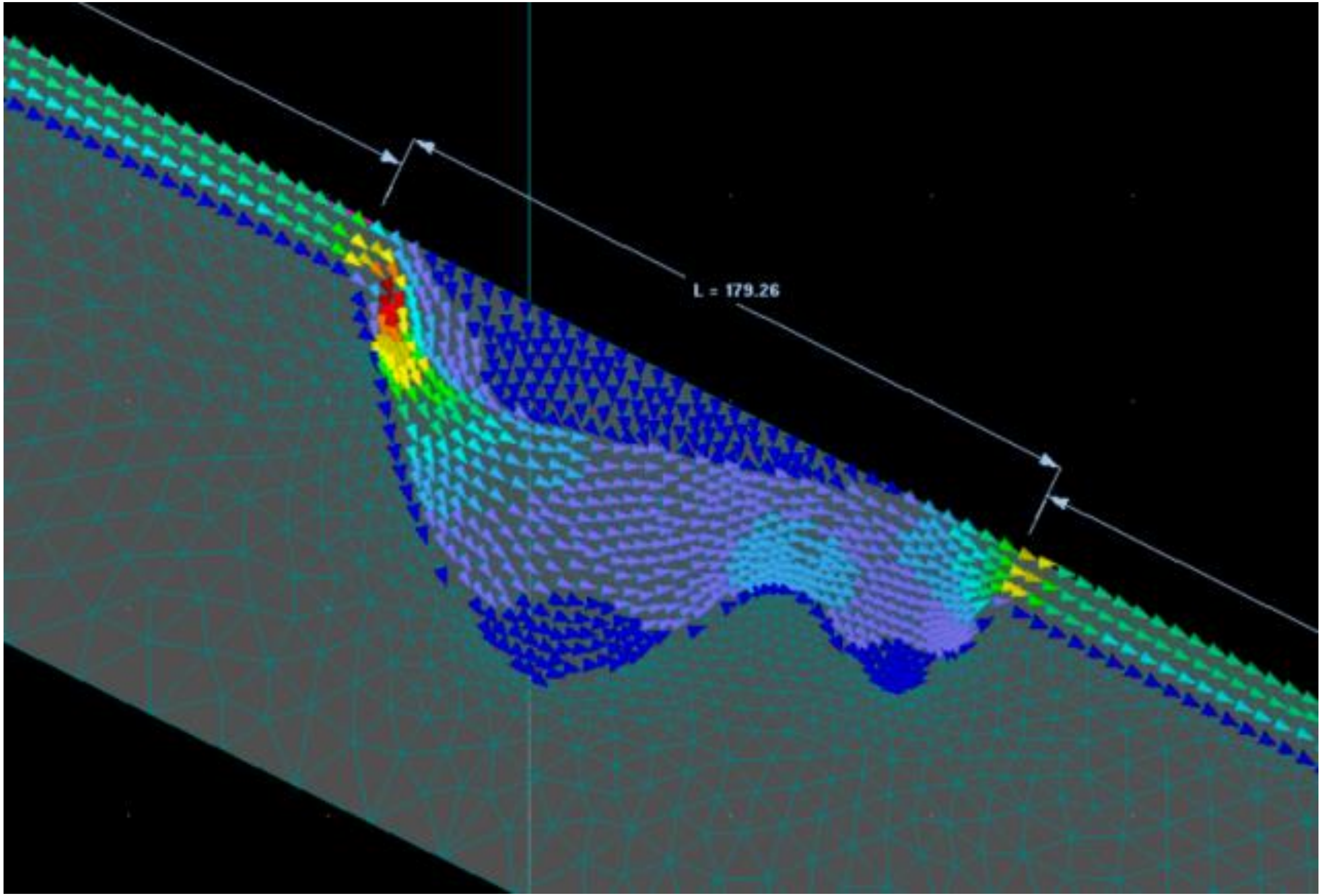
Whatever construction method is used, the loose, porous soil should rest on a horizontal base so that it does not move laterally when saturated.



Hydrus 2D model output showing water flow into a decompacted bench on a 2:1 slope.

Bear Creek Ranch
Vegetation
Restoration
of Damaged Roadside
Ultramafic Soils
BLM 2012

Figure 19d. At the end of the one hour 25 year IDF storm event, the treated area has water flow filling the pore volume. Water flow is just starting to spill out of the toe of the treatment plot (yellow arrows), indicating the capacity of the treatment has just been reached under these slope and storm scenario conditions.



Color indicates seep flow rates.

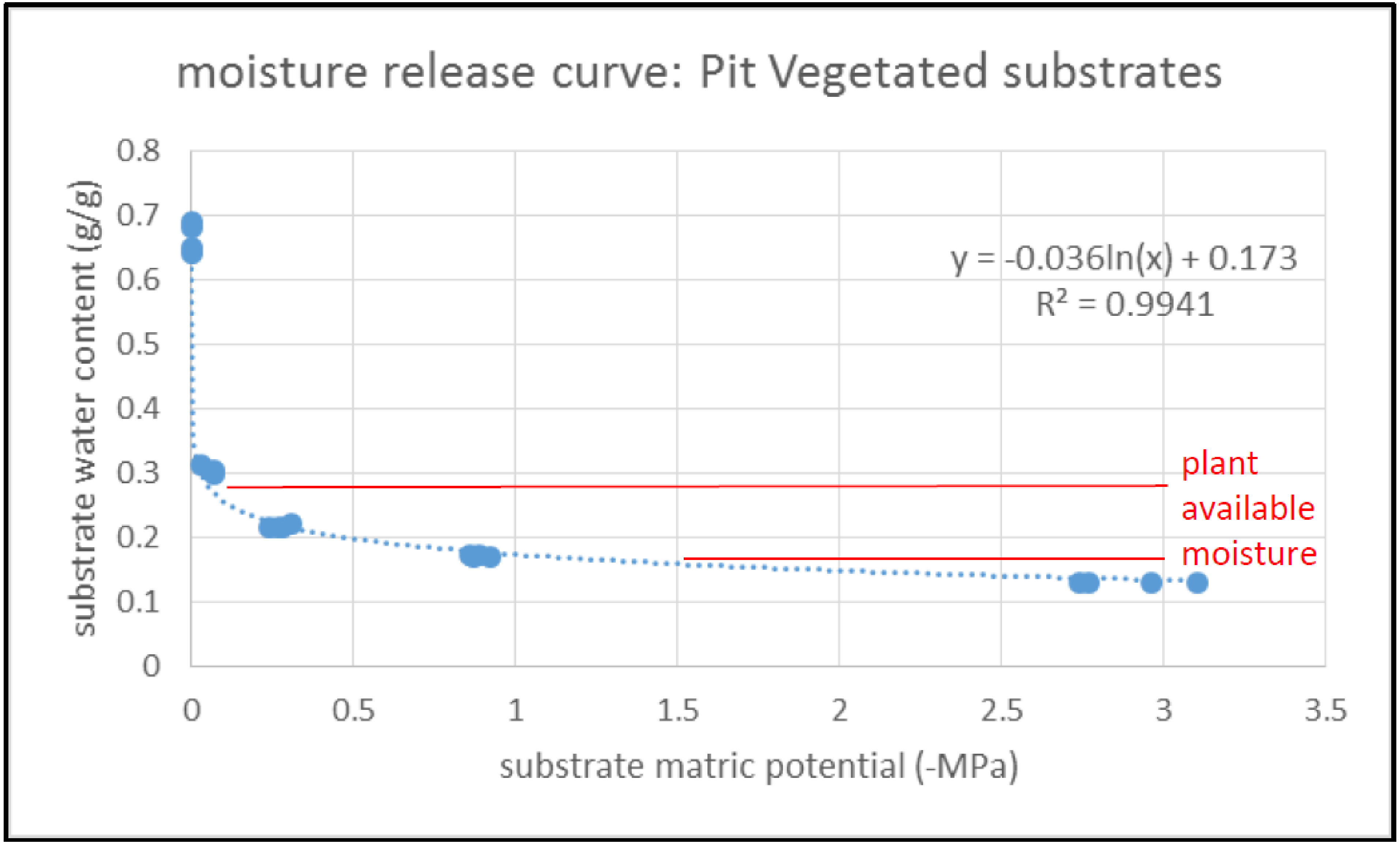
Red color is most rapid seep flow. Dark blue and gray are slow. The porous surface horizon conducts pore water downslope. Compacted subsurface has only slow flow.

Bulk amendment can occur in lifts if each lift is amended individually.

Conventional ripping treatments decompact subsurface horizons but do not incorporate surface-applied amendments effectively.

Both the volume of soil moisture and the matric potential with which it is held by the substrate were measured. Plants withdraw moisture to the limit of their wilting point.

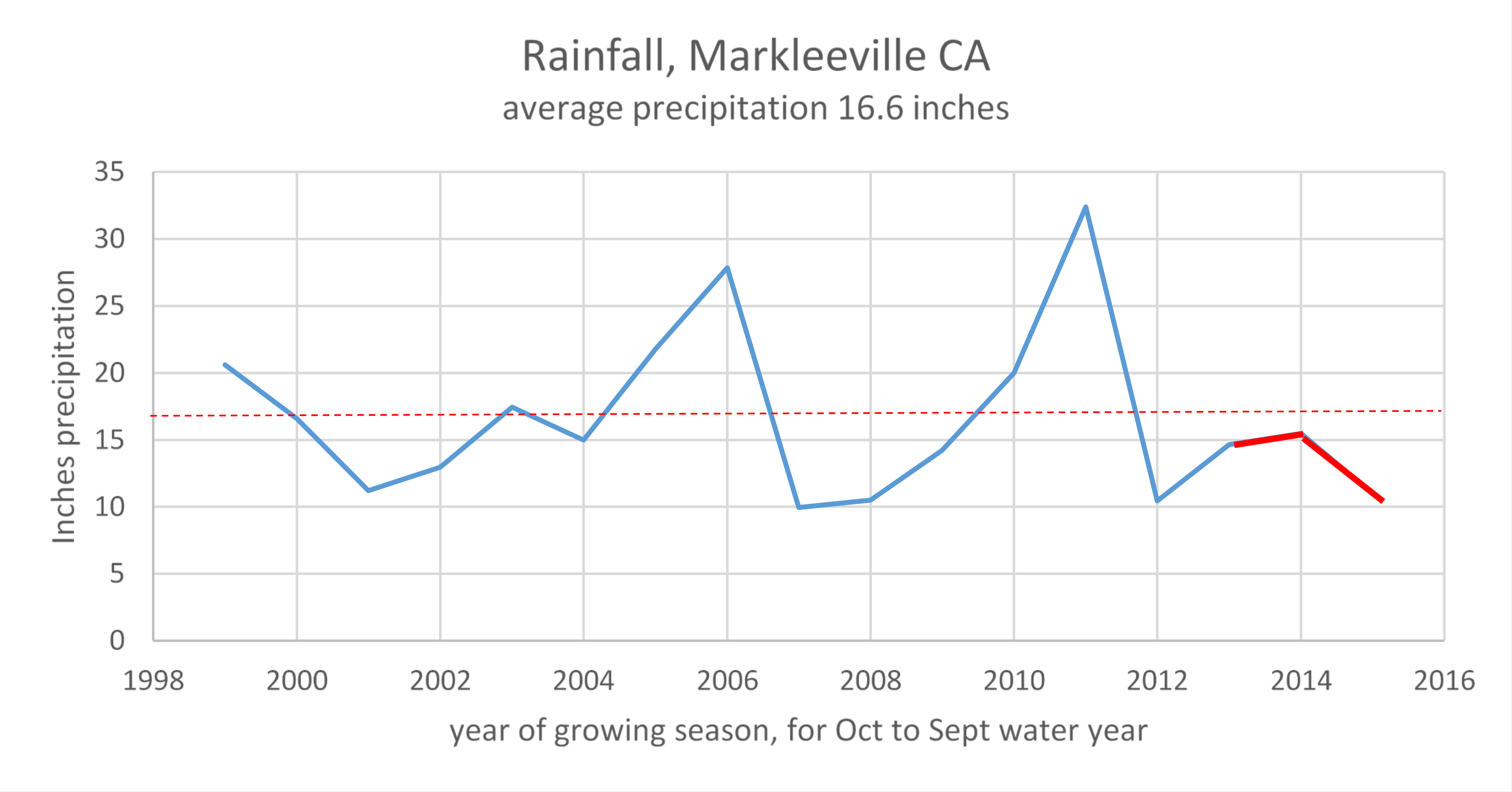
Figure 19. Soil moisture volumetric probe (left) and matric potential probe (right).



Moisture Release Curve

An advantage of deep decompaction is increased moisture retention

Figure 24. Substrate moisture release curve for vegetated pit substrates. Plants can extract moisture from about the cluster of points at 0.3 g/g moisture content down to about -1.5 MPa (to maybe -2.5 MPa, depending on species).



Non-average rainfall pattern

erratic weather requires erosion control for high rain and plant moisture for low rain periods

Figure 18. Variation in precipitation for water year (October 1 to Sept 30) and the 17 year average of 16.6 inches (dotted line). Date shown on graph is the year of the spring growing season. The vegetation evaluation period covers 2013, 2014 and 2015, shown in red on the graph.

Green, photosythentically active tissues continue to transpire soil moisture (early December, 2015). These plants continue to de-water the soil through the winter season. Different native plants provide different water use levels. Evergreen shrubs provide year-round moisture demand. Trees will have an even larger transpiration potential.

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Remaining Data Gaps

1. Leviathan substrate minerals are atypical and need to be characterized for potential to reacidify and for local mineral variability.

2. Compaction levels are poorly understood for geotechnical stability versus compaction levels that limit rooting growth.

3. Organic materials are important in regenerating soil properties but are not well specified.

4. Long term plant response to soluble fertilizers is only generally known.

5. The ability of plant cover to extract soil moisture for transpiration and to dewater the profile has been shown in a general way but not for different plant species, densities or weather conditions. Plant transpiration dewaters the profile and reduces acid mine drainage needing treatment.